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PASTE APPLICATION METHOD AND APPARATUS THEREFOR

[Abstract]

PROBLEM TO BE SOLVED: To heighten the productivity by increasing a paste application speed, suppressing the vibration of a movable part, and applying excellently a paste pattern in a desired shape by coating.

SOLUTION: A simulated coating operation without parting to a dummy substrate (a step 300) according to a paste pattern data is carried out (a step 600). The distance between the nozzle and the substrate is measured (a step 700) by the simulated coating operation and the coating position where a great vibration exceeding the allowance is searched (the step 700). In the case such a coating

position exists, the coating speed is corrected only at this coating position to a new coating speed (a step 1100), and at the same time the similar simulated coating operation is carried out at the new coating speed. The simulated coating operation is carried out while successively correcting the coating speed. In such a manner, at the coating position where vibration occurs, coating speed can be set corresponding to the magnitude of the generated vibration, but a coating speed at which no vibration occurs can be set.

[Claim(s)]

[Claim 1]

A paste coating method carried out in such a manner that a substrate is put on a table, facing against an outlet of a nozzle, and a relative distance between the substrate and the nozzle being in a vertical direction relative to the top surface of the substrate is maintained, varying a relative position relation between the substrate and the nozzle as paste that is filled in a paste storage receptacle is discharged through the outlet of the nozzle onto the substrate, thereby coating a paste pattern of a desired shape on the substrate, the paste coating method including: the step (1) of detecting the relative distance between the nozzle and the substrate in a vertical direction relative to the surface of the substrate, varying the relative position relation between the substrate placed on the table and the nozzle at a given relative movement velocity; the step (2) of determining whether the relative distance detected at the step (1) is in an allowable range set previously; the step (3) of setting a somewhat lower velocity than the given relative movement velocity to a new given relative movement velocity, when it is

determined that the relative distance is not in the allowable range, and detecting the relative distance between the nozzle and the substrate in the vertical direction relative to the surface of the substrate, varying the relative position relation between the substrate placed on the table and the nozzle at the new given relative movement velocity; and the step (4) of determining the given relative movement velocity as the relative movement velocity between the nozzle and the substrate on which the paste is discharged from the outlet of the nozzle to form the paste pattern of the desired shape, when it is determined at the step (2) that the relative distance is in the allowable range.

[Claim 2]

A paste coating device carried out in such a manner that a substrate is put on a table, facing against an outlet of a nozzle, and a relative distance between the substrate and the nozzle being in a vertical direction relative to the top surface of the substrate is maintained, varying a relative position relation between the substrate and the nozzle as paste that is filled in a paste storage receptacle is discharged through the outlet of the nozzle onto the substrate, thereby coating a

paste pattern of a desired shape on the substrate, the paste coating device comprising: a first unit (1) for detecting the relative distance between the nozzle and the substrate in a vertical direction relative to the surface of the substrate, varying the relative position relation between the substrate placed on the table and the nozzle at a given relative movement velocity; a second unit for determining whether the relative distance detected by means of the first unit is in an allowable range set previously; a third unit for setting a somewhat lower velocity than the given relative movement velocity to a new given relative movement velocity, when it is determined that the relative distance is not in the allowable range, and detecting the relative distance between the nozzle and the substrate in the vertical direction relative to the surface of the substrate, varying the relative position relation between the substrate placed on the table and the nozzle at the new given relative movement velocity; and a fourth unit for determining the given relative movement velocity as the relative movement velocity between the nozzle and the substrate on which the paste is discharged from the outlet of the nozzle to form the paste pattern of the desired shape, when

it is determined by the second unit that the relative distance is in the allowable range.

[Claim 3]

A paste coating device according to claim 2, further comprising: a fifth unit for determining whether the discharging pressure of paste from the outlet of the nozzle should be reduced, whenever the new given relative movement velocity is set by the third unit; a sixth unit for reducing by small amounts the discharging pressure of paste to be set from the outlet of the nozzle at the time when the patterning of the paste pattern is executed, if it is determined that the discharging pressure of paste should be reduced; and if it is determined that the relative distance is in the allowable range through the second unit, a seventh unit for setting the discharging pressure of paste obtained by the sixth unit as the discharging pressure of paste to be set from the outlet of the nozzle at the time when the patterning of the paste pattern is executed.

[Title of the Invention] Paste Coating Method and Paste Coating Device

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a paste coating method and a paste coating device that is carried out in such a manner that a substrate is put on a table, facing against an outlet of a nozzle, and a relative distance between the substrate and the nozzle being in a vertical direction relative to the top surface of the substrate is maintained, varying a relative position relation between the substrate and the nozzle as paste that is filled in a paste storage receptacle is discharged through the outlet of the nozzle onto the substrate, thereby coating a paste pattern of a desired shape on the substrate, and more particularly, to a paste coating method and a paste coating device that achieves high productivity.

[0002]

[Description of the Prior Art]

To improve the productivity in a conventional paste coating device, a relative movement velocity between a nozzle and a substrate, i.e. a velocity at a time of coating a paste pattern (hereinafter referred to as a coating velocity) is raised, while the paste that is filled in the paste storage receptacle is being discharged from the nozzle onto the substrate.

[0003]

[Problem(s) to be Solved by the Invention]

In the conventional paste coating device, by the way, if the coating velocity is raised, the straight line portion of the paste pattern is well formed, without any trouble, but the curved portion having a relatively small curvature radius of the paste pattern where the coating direction is changed to be right-angled is formed with vibration. In more detail, when the coating direction is changed from an axis X to an axis Y or from the axis Y to the axis X, the vibration occurs at the changed portion of the paste pattern. For example, in a case where a moving part becomes the nozzle and a fixed part becomes a substrate suction plate placed on the substrate (that is, in the case where the nozzle is moved relative to the substrate),

if the movement direction of the nozzle is changed, the vibration on the nozzle is generated in the vertical (an axis Z) direction or the horizontal (axes X and Y) direction with respect to the nozzle. More especially, the vibration is great in the vertical direction. In the same manner as above, in a case where the fixed part becomes the nozzle and the moving part becomes the substrate suction plate (that is, in the case where the substrate is moved), if the movement direction of the substrate suction plate is changed, the vibration on the substrate fixed on the top surface of the substrate suction plate is generated. More especially, the vibration is great in the vertical direction. Such the generation of vibration severely occurs to the peripheral surface of the substrate, especially to the corners. Thereby, the relative distance between the nozzle and the substrate is varied, which makes the coating precision greatly low.

[0004] That is to say, as shown in FIG. 10, a relative position distance between a nozzle 13a and a substrate 22 is varied in a range between δ - z, and thus, an amount of paste coated per unit time is varied such that a paste pattern 23 of a desired shape is not obtained. As the coating velocity becomes higher, moreover,

the relative position distance between the nozzle 13a and the substrate 22 is greatly varied. Thereby, it is impossible to raise the coating velocity, which does not achieve any improvement of the productivity.

[0005] Accordingly, the present invention has been made in view of the above-mentioned problems occurring in the prior art, and an object of the present invention is to provide a paste coating method and a paste coating device that can raise a coating velocity to thereby obtain high productivity, coating a paste pattern having a desired shape.

[0006]

[Means for Solving the Problem]

To achieve the above object, according to an aspect of the present invention, there is provided a paste coating method carried out in such a manner that a substrate is put on a table, facing against an outlet of a nozzle, and a relative distance between the substrate and the nozzle being in a vertical direction relative to the top surface of the substrate is maintained, varying a relative position relation between the substrate and the nozzle as paste that is filled in a paste

storage receptacle is discharged through the outlet of the nozzle onto the substrate, thereby coating a paste pattern of a desired shape on the substrate, the paste coating method including: the step (1) of detecting the relative distance between the nozzle and the substrate in a vertical direction relative to the surface of the substrate, varying the relative position relation between the substrate placed on the table and the nozzle at a given relative movement velocity; the step (2) of determining whether the relative distance detected at the step (1) is in an allowable range set previously; the step (3) of setting a somewhat lower velocity than the given relative movement velocity to a new given relative movement velocity, when it is determined that the relative distance is not in the allowable range, and detecting the relative distance between the nozzle and the substrate in the vertical direction relative to the surface of the substrate, varying the relative position relation between the substrate placed on the table and the nozzle at the new given relative movement velocity; and the step (4) of determining the given relative movement velocity as the relative movement velocity between the nozzle and the substrate on which the paste is discharged from the outlet of the nozzle to

form the paste pattern of the desired shape, when it is determined at the step (2) that the relative distance is in the allowable range.

[0007] According to another aspect of the present invention, there is provided a paste coating device carried out in such a manner that a substrate is put on a table, facing against an outlet of a nozzle, and a relative distance between the substrate and the nozzle being in a vertical direction relative to the top surface of the substrate is maintained, varying a relative position relation between the substrate and the nozzle as paste that is filled in a paste storage receptacle is discharged through the outlet of the nozzle onto the substrate, thereby coating a paste pattern of a desired shape on the substrate, the paste coating device comprising: a first unit (1) for detecting the relative distance between the nozzle and the substrate in a vertical direction relative to the surface of the substrate, varying the relative position relation between the substrate placed on the table and the nozzle at a given relative movement velocity; a second unit for determining whether the relative distance detected by means of the first unit is in an allowable range set previously; a third unit for setting a somewhat lower

velocity than the given relative movement velocity to a new given relative movement velocity, when it is determined that the relative distance is not in the allowable range, and detecting the relative distance between the nozzle and the substrate in the vertical direction relative to the surface of the substrate, varying the relative position relation between the substrate placed on the table and the nozzle at the new given relative movement velocity; and a fourth unit for determining the given relative movement velocity as the relative movement velocity between the nozzle and the substrate on which the paste is discharged from the outlet of the nozzle to form the paste pattern of the desired shape, when it is determined by the second unit that the relative distance is in the allowable range.

[0008]

[Embodiment of the Invention]

Hereinafter, an explanation of the paste coating method and paste coating device according to an embodiment of the present invention is given with reference to the accompanying drawings. FIG. 1 is a perspective view showing the

structure of a paste coating device according to the present invention. Reference numeral 1 denotes a mount, 2a and 2b denote substrate returning conveyors, 3 denotes a support stand, 4 denotes a substrate suction plate, 5 denotes a θ–direction movement table, 6a and 6b denote X-axis movement tables, 7 denotes a Y-axis movement table, 8a and 8b denote servo motors, 9 denotes a Z-axis movement table, 10 denotes a servo motor, 11 denotes a ball screw, 12 denotes a servo motor, 13 denotes a paste storage receptacle (syringe), 14 denotes a distance meter, 15 denotes a support plate, 16a and 16b denote an image recognizing camera, 17 denotes a control unit, 18 denotes a monitor, 19 denotes a keyboard, 20 denotes a personal computer body provided with an external memory unit, and 21 denotes a cable.

[0009] As shown in FIG. 1, the substrate returning conveyors 2a and 2b are ascendably disposed in parallel relation to each other in a direction of an axis X on the mount 1, for returning a substrate which is not shown to the front of the drawing from the inside thereof, that is, for returning the substrate horizontally in the direction of the axis X. Further, the support stand 3 is located on the mount 1,

and the substrate suction plate 4 is placed on the support stand 3, placing the θ–direction movement table 5 between the substrate suction plate 4 and the support stand 3. The θ–direction movement table 5 serves to rotate the substrate suction plate 4 in the θ direction that is made by the rotation of an axis Z.

[0010] Further, the X-axis movement table 6a and 6b are disposed in parallel relation to each other with respect to the direction of the axis X at the outer sides of the mount 1 separated by a given distance from the substrate returning conveyors 2a and 2b, and the Y-axis movement table 7 is disposed horizontally between the X-axis movement tables 6a and 6b. The Y-axis movement table 7 is returned horizontally to its original position by the forward rotation or the rotation of the backward rotation (forward-backward rotation) of the servo motors 8a and 8b mounted on the X-axis movement tables 6a and 6b. The Z-axis movement table 9 that is moved in the direction of an axis Y by the forward and backward rotation of the ball screw 11 by the driving of the servo motor 10 is disposed on the Y-axis movement table 7. The support plate 15 is located on the Z-shaft movement table 9, for fixedly supporting the paste storage receptacle 13 and the distance meter 14.

The servo motor 12 serves to guide the paste storage receptacle 13 and the distance meter 14 in the direction of the axis Z through the driving part of a linear guide (which is not shown) mounted on the support plate 15. The paste storage receptacle 13 is detachably mounted on the driving part of the linear guide. The mount 1 is provided on the ceiling plate thereof with the image recognizing cameras 16a and 16b that are located upwardly, for adjusting the position of the substrate.

[0011] The mount 1 is provided at the inside thereof with the control unit 17 that controls the servo motors 8a, 8b, 10, 12, and 24 (which is not shown), connected to the monitor 18, the keyboard 19 and the PC body 20 through the cable 21. The data for the various processes of the control unit 17 is inputted by the keyboard 19 and the images photographed by the image recognizing cameras 16a and 16b and the process situations in the control unit 17 are displayed on the monitor 18.

[0012] The data inputted by the keyboard 19 is sent to a memory medium like a floppy disc in the external memory unit of the PC body 20.

[0013] FIG. 2 is an enlarged perspective view showing the paste storage receptacle 13 and the distance meter 14 of FIG. 1, wherein reference numeral 13a denotes a nozzle, 22 denotes a substrate, and 23 denotes a paste pattern, wherein the parts corresponding to those of FIG. 1 are indicated by corresponding reference numerals.

[0014] As shown in FIG. 2, the distance meter 14 is provided at the lower end thereof with a triangular cut portion that has a light emitting diode and a plurality of light receiving diodes thereon. The nozzle 13a is positioned under the distance meter 14. The distance meter 14 measures a distance from the front end portion of the nozzle 13a to the surface (top surface) of the substrate 22 by using a non-contact triangulation method. That is, the light emitting diode is disposed at the one side inclined surface of the triangular cut portion, and laser light L emitted from the light emitting diode is reflected at a measuring point S on the substrate 22 and is received through any of the plurality of light receiving diodes on the other side inclined surface of the triangular cut portion. Therefore, the laser light

L is not cut off by the formation of the paste storage receptacle 13 and the nozzle 13a.

[0015] On the other hand, the measuring point S of the substrate 22 at which the laser light L is reflected is misaligned by substantially short distances ΔX and ΔY with the substrate 22 placed just under the nozzle 13a. Since the height (concave and convex) on the surface of the substrate 22 is relatively constant, even with having the distance differences ΔX and ΔY, it is therefore appreciated that there is little difference between the measured result of the distance meter 14 and the distance between the front end portion of the nozzle 13a and the surface of the substrate 22. As the servo motor 12 is controlled based upon the measuring result of the distance meter 14, the distance between the front end portion of the nozzle 13a and the surface of the substrate 22 is constantly maintained according to the height of the surface of the substrate 22, such that the width and thickness of the paste pattern 23 coated on the substrate 22 are all kept constant.

[0016] FIG. 3 is a block diagram showing the construction of the control unit 17, the control of the air pressure of the paste storage receptacle 13, and the control

of the substrate 22. Reference numeral 17a denotes a microcomputer, 17b denotes a motor controller, 17c1 and 17c2 denote X1-axis and X2-axis drivers, 17d denotes a Y-axis driver, 17e denotes a θ–axis driver, 17f denotes a Z-axis driver, 17g denotes a data communication bus, 17h denotes an external interface, 24 denotes a servo motor driving the θ–direction movement table 5 (see FIG. 1), 25 to 29 denote encoders, 30 denotes a positive pressure source, 30a denotes a positive pressure regulator, 31 denotes a negative pressure source, 31a denotes a negative pressure regulator, and 32 denotes a valve unit, wherein the parts corresponding to those of FIGS. 1 and 2 are indicated by corresponding reference numerals.

[0017] As shown in FIG. 3, the control unit 17 integrally has the microcomputer 17a, the motor controller 17b, the X, Y, Z and θ axes drivers 17c1 to 17f, the image processing unit 17i for processing the image signals obtained from the image recognizing cameras 16a and 16b, and the external interface 17h for transmitting signals to the keyboard 19. The control unit 17 further includes a driving control

system of the substrate returning conveyors 2a and 2b that is not shown in the drawing.

[0018] The microcomputer 17a includes a read-only memory (ROM) in which a main operating part and a processing program for conducting the paste pattern to be coated as will be discussed later are stored, a random access memory (RAM) in which the process result of the main operating part and the input data from the external interface 17h and the motor controller 17b are stored, and an input and output part that exchanges the data with the external interface 17h and the motor controller 17b. The servo motors 8a, 8b, 10, 12 and 24 mount corresponding encoders 25 to 29 for detecting the amount of rotation. The detected results are sent to the X, Y, Z and θ axes drivers 17c1 to 17f through which position control is conducted.

[0019] As the servo motors 8a, 8b and 10 are rotated forwardly and backwardly based upon the data stored in the RAM of the microcomputer 17a inputted through the keyboard 19, the nozzle 13a (see FIG. 2) is moved by an arbitrary distance in the directions of the axes X and Y through the Z-axis movement table

9 (see FIG. 1), with respect to the substrate 22 placed in vacuum sucking manner on the substrate sucking plate 4 (see FIG. 1) by the negative pressure sent from the negative pressure source 31. During the movement as the microcomputer 17a controls the valve unit 32, a relatively small amount of air pressure is applied from the positive pressure source 30 to the paste storage receptacle 13 through the positive pressure regulator 30a and the valve unit 32, such that the paste is discharged from the outlet of the front end portion of the nozzle 13a and coated on the substrate 22 to a desired pattern. While the Z-axis movement table 9 is moved horizontally to the directions of the axes X and Y, the distance meter 14 measures the distance between the nozzle 13a and the substrate 22, and in order to maintain the distance constantly, the servo motor 12 is controlled by means of the Z-axis driver 17f.

[0020] In the stand-by state where the paste coating is not carried out, the microcomputer 17a controls the valve unit 32 to communicate the negative pressure source 31 with the paste storage receptacle 13 through the negative pressure regulator 31a and the valve unit 32 to thereby return the paste being

discharged from the outlet of the nozzle 13a to the paste storage receptacle 13 again. Thereby, the leakage of the paste liquid from the outlet can be prevented. Also, the outlet of the nozzle 13a is monitored by means of an image recognizing camera which is not shown, and only when the leakage of the paste occurs, the microcomputer 17a controls the valve unit 32 to communicate the negative pressure source 31 with the paste storage receptacle 13.

[0021] FIG. 4 is a flowchart showing the whole operation of the preferred embodiment of the present invention in FIG. 1.

[0022] As shown in FIG. 4, if power is applied to the paste coating device according to the present invention (at step 100), an initial setting starts (at step 200). In the initial setting process, the servo motors 8a, 8b and 10 as shown in FIG. 1 are driven to move the Z-axis movement table 9 in the directions of axes X and Y thus to a given reference position and set the nozzle 13a (see FIG. 2) to a given original position thus to determine a position (a paste coating starting point) where the paste outlet of the nozzle starts to discharge the paste. At the same time, setting is conducted for the data of one or more paste patterns

(hereinafter referred to paste pattern data) coated on the substrate (hereinafter referred to as a real substrate) on which paste pattern is formed, for the position data of the real substrate, for the data of relative velocity (which is referred to as coating velocity, especially as an initial set coating velocity) between the real substrate on which the paste is being really coated and the nozzle, for the data of height (which is referred to as coating height, especially as an initial set coating height) of the nozzle from the surface of the substrate, the data of pressure (which is referred to as coating pressure, especially as an initial set coating pressure) applied to the paste storage receptacle 13 which determines an amount of paste discharging from the nozzle, for the position data of the paste discharging ending, and for the measuring position data of the coated paste pattern. The input of the various kinds of data is executed by means of the keyboard 19 (see FIG. 1) and stored in the RAM in the microcomputer 17a (see FIG. 3).

[0023] If the initial setting processing ends (at step 200), a dummy substrate (which is not shown), which is used to determine whether the paste pattern of the desired shape is coated with high precision, is supportably placed on the

substrate suction plate 4 (at step 300). In the mounting process of the dummy substrate, the dummy substrate is delivered upwardly of the substrate suction plate 4 in the direction of axis X through the substrate returning conveyors 2a and 2b and is then placed on the substrate suction plate 4 as the substrate returning conveyors 2a and 2b are descended by means of an elevating device (which is not shown).

[0024] After that, a paste coating operation (paste coating simulation operation) is simulated by using the dummy substrate to determine whether vibration occurs on the working part upon operation of paste coating. An aim of executing the paste coating simulation operation is to detect the position of the generation of vibration of the working part when the paste pattern is formed on the real substrate and at the same time to obtain a maximum coating velocity at which the vibration on the position is not generated, and a coating height and a coating pressure with respect to the coating velocity. And, the initial set coating velocity, the initial set coating height, and the initial set coating pressure that are made at

the initial set processing (at the step 200) are obtained by those made when the straight line portion of the paste pattern is coated with lots of experiences.

[0025] In the paste coating simulation operation, the existence and non-existence of vibration is determined by the variation of distances between the nozzle 13a and the substrate 22 (see FIG. 2), and at this time, the distance meter 14 is used as a vibration measuring sensor. Also, the number of the paste patterns used in the paste coating simulation operation is n (in this case, the symbol n denotes the whole number over 2). As described above, the paste pattern data is inputted from the keyboard 19 (see FIG. 1) and then stored in the RAM (hereinafter, simply referred to as memory) of the microcomputer 17a (see FIG. 3), in the orders used on the paste coating on the real substrate, for example, in the orders of numbers 1, 2, ······, and n.

[0026] Upon starting the paste coating simulation operation, the distance meter 14 used as the vibration measuring sensor is first positioned to a given height on the dummy substrate (at step 400). And, the paste pattern data used in the paste coating simulation operation is selected from the paste pattern data stored in the

memory and the data number is stored in the memory. At the first time, the paste pattern data of No. 1 is selected (at step 500).

[0027] Next, the microcomputer 17a (see FIG. 3) controls the servo motors 8a, 8b and 10 by using the paste pattern data of No. 1 to move the nozzle 13a at the initial set coating velocity along the paste pattern made by the paste pattern data of No. 1, thereby starting the paste coating simulation operation (at step 600). In this case, the paste is not discharged from the nozzle 13a and the servo motor 12 is not controlled.

[0028] The distance between the nozzle 13a and the substrate 22 is sequentially measured by the distance meter 14, together with the starting of the paste coating simulation operation, and the measured distance data that is considered as the distance data in a vertical direction is associated with the position data of the paste pattern data and then stored in the memory (at step 700).

[0029] FIG. 5 is a flowchart showing the distance measurement process (step 700) of FIG. 4.

[0030] As shown in FIG. 5, the distance between the nozzle 13a and the substrate 22 is sequentially measured by the distance meter 14 (at step 710), and the measured distance data that is considered as the distance data is associated with the position data and stored in the memory (at step 720). The measurement and storage process of the distance data is kept until the paste pattern of No. 1 in the paste coating simulation operation is completely formed (at step 730).

[0031] If the distance measurement process ends (at the step 700), the distance meter 14 is moved upwardly (at step 800), and a step of searching the positions of the generation of vibration on the paste pattern and determining whether the vibration is in an allowable range with the obtained distance data (at step 900).

[0032] FIG. 6 is a flowchart showing the searching and determining processes (the step 900) for the paste pattern on which vibration is generated.

[0033] As shown in FIG. 6, it is determined whether the distance data to be searched and determined exists or not (step 910), and if the searching and determining step of the distance data is finished, it is determined that there is no distance data to be searched and determined. At this time, a value 0 is

substituted to a variable V_F for allowable range determining flag (at step 950). Meanwhile, if the searching and determining step of the distance data is not finished yet, next distance data is read to execute the data conversion (at step 920).

[0034] The data conversion process is explained with reference to FIG. 7 showing the distance data (waveform 1) obtained by the distance measurement. The gentle height of the distance data is obtained by the height of the surface of the dummy substrate, and since the servo motor 12 is not controlled, the variation of distance between the nozzle 13a and the substrate 22 is measured by the distance meter 14. The drastic variation at a portion a of the distance data is made by the upward and downward vibration of the distance meter 14 (that is, the nozzle 13a), which is generated when the moving direction of the nozzle 13a is changed at the state where the coating velocity is very fast, that is, at the state the moving velocity of the nozzle 13a is very fast.

[0035] To determine whether the vibration portion as shown in FIG. 7(a) is in the previously set allowable range, the variation values by the height of surface of the

dummy substrate are removed from the distance data, and the data conversion is executed such that the variation values by the vibration of the nozzle 13a are markedly shown. As one method of the data conversion is provided a method of executing differential calculus for the distance data, and the data obtained by the method is shown in FIG. 7(b).

[0036] As shown in FIG. 7(b), the variation values by the height of the surface of the dummy substrate are in the allowable range, and the variation values by the vibration of the nozzle 13a are markedly shown.

[0037] At step 930 of FIG. 6, it is determined whether a portion b being not in the allowable range with respect to the converted distance data exists or not. If one or more portions b exist, the position data (that is, the position on the paste pattern by the paste pattern data) of the paste pattern data of No. 1 of the portions b being not in the allowable range is detected and at the same time, a value 1 is substituted to the variable V_F for allowable range determining flag (at step 940). The determining process is executed to the end of the distance data detected with respect to the paste pattern data of No. 1 (at step 910), and if there is no portions

b being not in the allowable range (at step 930), the value 0 is substituted to the variable V_F for allowable range determining flag (at the step 950).

[0038] The data conversion of the distance data is not limited to the differential calculus method and can be carried out by using various methods, for example, a difference value between front data value and back data value, if it is possible to suppress the variation values by the height of the surface of the dummy substrate and to markedly show those by the vibration of the nozzle 13a.

[0039] The above-described processes are carried out at the step 900 of FIG. 4, whereby the position of generation of vibration is detected in the first paste coating simulation operation where the coating velocity of the paste pattern data of No. 1 is set as the initial set coating velocity. Thereby, at the position where the vibration is not generated, the coating velocity at the time of the real paste coating of the real substrate with the paste pattern data of No. 1 can be set as the initial set coating velocity.

[0040] If the step 900 is finished, it is determined whether the value of the variable V_F is 1 (at step 1000). If the value is 1, a coating condition correction step starts

(at step 1100). Hereinafter, an explanation of the coating condition correction step (the step 1100) is given with reference to FIG. 8.

[0041] As shown in FIG. 8, the initial set coating velocity is low by a previously set value, which is set as a new coating velocity (at step 1110).

[0042] By the way, in the case where the coating velocity is reduced, the amount of paste discharging form the nozzle per unit movement distance becomes large such that the width of the paste pattern becomes larger and the height thereof becomes of course higher, thereby making it impossible to obtain the paste pattern of the desired shape. In this case, therefore, there is a need for reduction of the discharging pressure of the paste, that is, the coating pressure, to thereby decrease the amount of paste discharging, which enables the paste pattern of the desired shape to be achieved.

[0043] After that the initial set coating velocity is low by a previously set value to set the low coating velocity as the new coating velocity at the step 1110, it is determined whether the coating pressure with respect to the new coating velocity should be reduced (at step 1120). If it is determined that the coating pressure

should be reduced, the coating pressure by the previously set difference value is reduced based upon the reduced value of the new coating velocity (at step 1130).

[0044] Next, it is determined whether the set height of the nozzle (coating height) upon coating should be varied with respect to the new coating velocity (at step 1140). If it is determined that the coating height should be varied, in the same manner as the coating pressure, the coating height by the previously set difference value is raised based upon the varied value of the new coating velocity (at step 1150).

[0045] If the step 1100 is finished, the coating velocity, the coating pressure, and the coating height at the vibration generation positions detected in the first paste coating simulation operation using the paste pattern data of No.1 are determined as the newly set coating velocity, pressure and height. A second paste coating simulation operation is executed at the step 400 using the paste pattern data of No. 1 with the new coating velocity, pressure and height.

[0046] In the second paste coating simulation operation, in the case where the position of generation of vibration being not in the allowable range exists, at the

coating condition correction process (the step 1100) the coating velocity used at this step is corrected in the above manner to set a new coating velocity and at the same time, the coating pressure and the coating height are changed if necessary (at the steps 1130 and 1150 in FIG. 8). Thus, the coating velocity, pressure, and height at the position of generation of vibration being not in the allowable range are changed to newly corrected coating velocity, pressure, and height. Also, in the second paste coating simulation operation at the position of generation of vibration being in the allowable range, the new coating velocity, pressure, and height that are obtained in the first paste coating simulation operation are just used, without any correction.

[0047] In the second paste coating simulation operation if the newly corrected coating velocity, pressure, and height are obtained, a third paste coating simulation operation is executed at the step 400 using the paste pattern data of No. 1 with the newly corrected coating velocity, pressure, and height. Then, the operation is executed until the variable V_F is 0 (at the step 1100). Thus, the coating velocity, pressure, and height of each position on the paste pattern

relative to the paste pattern data of No.1 are obtained. In this case, the initial set coating velocity, pressure, and height are assigned to each position on the straight line portion of the paste pattern, and the coating velocity becomes low to each position where relatively large vibration is generated, which makes the coating pressure and height newly determined according to the low coating velocity.

[0048] FIG. 9 is a view of describing the data obtained by the above-discussed paste coating simulation operations, wherein the coating positions on the paste pattern relative to the paste pattern data of No. 1 are designated as S1 to S7.

[0049] FIG. 9(a) shows an initial paste coating simulation operation, where the initial set coating velocity is designated as V_0, the initial set coating pressure is designated as F_0, and the initial set coating height is designated as H_0. If the vibration being not in the allowable range is generated at the coating positions S2 and S5 in the initial paste coating simulation operation, the coating velocity at the coating positions S2 and S5 is corrected from the initial set coating velocity V_0 to the new coating velocity V_1, as shown in FIG. 9(b) (In this case, it is necessary to

correct the coating pressure at the coating positions S2 and S5 from the initial set coating pressure F_0 to the new coating pressure F_1, and it is not necessary to correct the coating height). The second paste pattern simulation operation is executed at the new coating velocity V_1. If the vibration being not in the allowable range is generated at the coating position S2 in the second paste coating simulation operation, the coating velocity at the coating positions S2 and S5 is corrected from the initial set coating velocity V_1 to the new coating velocity V_2, as shown in FIG. 9(c) (In this case, it is not necessary to correct the coating pressure, and it is necessary to correct the coating height from the initial set coating height H_0 to the new coating height H_1). The third paste pattern simulation operation is executed at the new coating velocity V_2. If the vibration being not in the allowable range is not generated at any coating position in the third paste coating simulation operation, the simulation operations using the paste pattern data of No. 1 are all finished, and thus, the coating velocity, pressure, and height of each position on the paste pattern relative to the paste pattern data of No.1 are determined as those in FIG. 9(c).

[0050] If the simulation operations using the paste pattern data of No. 1 are all finished (at the step 1000), the paste pattern data of No. 2 is selected (at the step 1200) and the above-discussed simulation operations at the step 400 are repeated. Thus, the simulation operations using the paste pattern data of Nos. 3, 4,..., and n-1 are executed. In this case, in the first paste coating simulation operation of each paste pattern data the coating velocity, pressure, and height are determined as the initial set coating velocity, pressure, and height that are used at the step 200.

[0051] If the variable V_F of all paste pattern data inclusive of the paste pattern data of No. n is 0 and the simulation operations are all finished (at the step 1200), the coating velocity, pressure, and height at each position on the paste pattern with respect to each paste pattern data are set, and thereby, the conditions are set where the vibration on the nozzle 13a does not give any influence to the precision of the paste pattern upon coating the paste pattern on the real substrate. Next, the dummy substrate is drawn (at the step 1300), and the patterning on the real substrate as will be discussed below is executed (patterning of the paste pattern).

[0052] First, the real substrate is supportably placed on the substrate suction plate 4 (see FIG.1) (at the step 1400). In the real substrate mounting process, the real substrate is sent upwardly of the substrate suction plate 4 in the direction of the axis X by using the substrate returning conveyors 2a and 2b (see FIG. 1) and is then placed on the substrate suction plate 3 by descending the substrate returning conveyors 2a and 2b by means of the elevating means which is not shown.

[0053] Next, a substrate preparing position determining process (step 1500) is executed. In this process, the real substrate is positioned in the directions of the axes X and Y by means of a position determining chuck which is not shown in FIG. 1. A position determining mark of the real substrate mounted on the substrate suction plate 4 is photographed by means of the image recognizing cameras 16a and 16b, and the weight center position of the position determining mark is obtained in an image process to detect an inclination of the real substrate in the direction of θ. Thereby, the servo motor 24 (see FIG. 3) is driven to correct the inclination of the real substrate in the direction of θ.

[0054] Moreover, if there is a possibility that as the amount of paste remaining in the paste storage receptacle 13 becomes smaller, the paste is all exhausted during the coating operation of the paste pattern, the paste storage receptacle 13 is previously exchanged, together with the nozzle 13a. When the nozzle 13a is exchanged, the mounting position is somewhat changed when compared with the position before the exchange, which of course makes the reproduction low. Therefore, so as to prevent the reproduction from being low, the paste is coated in a crossed shape at the position where the paste is not coated yet on the real substrate by using the exchanged new nozzle 13a. The weight center position of the point of intersection of the crossed coating pattern is obtained in the image process, and a distance between the weight center position of the intersection and the weight center position of the position determining mark of the real substrate is calculated. The distance is set as amounts of the position misalignment dx and dy (see FIG. 2) of the paste outlet of the nozzle 13a and then stored in the RAM of the microcomputer 17a. This becomes the substrate preparing position determining process for the real substrate (at the step 1500),

and the position misalignment of the nozzle 13a upon coating of the paste pattern to be executed later is corrected by using the amounts of the position misalignment dx and dy of the nozzle 13a.

[0055] Next, the paste pattern coating process (at step 1600) is executed in the orders of the paste pattern data of No. 1, No. 2, No. 3, ..., and No. n. In this process, the Z-axis movement table 9 (see FIG. 1) is moved to execute comparing and adjusting movements of the nozzle 13a, such that the outlet of the nozzle 13a is positioned at the coating starting position. Before this process, it is first determined that the amounts of the position misalignment dx and dy of the nozzle 13a that are obtained in the substrate preparing position determining process (at the step 1500) and are stored in the RAM of the microcomputer 17a are in the allowable range values ΔX and ΔY of the amounts of the position misalignment of the nozzle 13a in FIG. 2. If the amounts of the position misalignment dx and dy of the nozzle 13a is in the allowable range (that is, if $\Delta X \geq dx$ and $\Delta Y \geq dy$), the position of nozzle is determined at the coating starting position, without any movement. Contrarily, if the amounts of the position misalignment dx and dy of

the nozzle 13a are not in the allowable range (that is, if ΔX < dx and ΔY < dy), the Z-axis movement table 9 is moved based upon the amounts of the position misalignment dx and dy of the nozzle 13a, to adjust the position of the paste storage receptacle 13, such that the misalignment between the outlet of the nozzle 13a and the desired position of the real substrate is removed thus to position the nozzle 13a at the desired position.

[0056] Next, the height setting of the nozzle 13a is executed. When the paste storage receptacle 13 is not exchanged, the data of the amounts of the position misalignment dx and dy of the nozzle 13a does not exist and thus, when the paste pattern coating process (at the step 1600) starts, the height setting of the nozzle 13a is just conducted. The set height is the initial set coating height of the nozzle 13a used in the paste coating simulation operation previously executed. The thickness from the outlet of the nozzle 13a to the surface of the substrate becomes the thickness of the paste, that is, the coating height.

[0057] When the above process is finished, next, the servo motors 8a, 8b, and 10 (see FIG. 1) are driven based upon the paste pattern data stored in the RAM of the

microcomputer 17a, and thereby, the nozzle 13a is moved in the directions of axes X and Y on the basis of the paste pattern data, facing the outlet against the real substrate. At the same time, an air pressure is a little applied from the positive pressure source 30 (see FIG. 3) to the paste storage receptacle 13 such that the paste starts to be discharged from the outlet of the nozzle 13a. The coating velocity at this time is the initial set coating velocity of the nozzle 13a used in the paste coating simulation operation previously executed, and the air pressure is obtained by the initial set coating pressure of the nozzle 13a used in the paste coating simulation operation previously executed. Thereby, the coating of the paste pattern on the real substrate is started at the coating velocity used in the paste coating simulation operation previously executed.

[0058] Together with the starting of the coating operation, the coating velocity, pressure, and height are controlled in accordance with the coating positions of the paste pattern, based upon the data obtained in the paste coating simulation operation previously executed. For example, when referring to the data shown in FIG. 9(c), the coating velocity becomes V_0, the coating pressure becomes F_0, and

the coating height becomes H_0, at the coating position S1. When adjacent to the coating position S2, the coating velocity becomes V_1, the coating pressure becomes F_1, and the coating height becomes H_1. Thereby, when the paste coating at the coating position S2 is conducted, the vibration being not in the allowable range is not generated on the working part. Also, when the coating position S2 is passed, the coating velocity, the coating pressure, and the coating height are returned to the original coating velocity, pressure, and height V_0, F_0, and H_0. Next, when adjacent to the coating position S5, the coating velocity is changed to V_1 and the coating pressure is changed to F_1.

[0059] Together with the patterning of the paste pattern, the data of distance between the outlet of the nozzle 13a and the surface of the real substrate by using the distance meter 14 is inputted to the microcomputer 17a to thereby measure the height of the surface of the real substrate. The servo motor 12 is driven based upon the measured height value, such that the set height of the nozzle 13a from the surface of the real substrate is kept constantly, thereby conducting the coating patterning of the paste pattern.

[0060] The coating patterning of the paste pattern is kept on, and the determination whether the coating patterning operation of the paste pattern is continued or stops is made when it is determined whether the coated point is an ending point of the paste pattern to be coated determined by the paste pattern data. If the coated point is not the ending point, the measuring process of the height of the surface of the real substrate is executed again, and next, each process as discussed above is repeated until the coated point reaches the coating ending of the paste pattern.

[0061] The coating operation of the paste pattern is executed with respect to the n number of paste pattern data, and if the coated point reaches the coating ending of the paste pattern by the last paste pattern data of No. n, the servo motor 12 is driven to ascend the nozzle 13a. Thus, the paste pattern coating process (at the step 1600) is finished.

[0062] Next, a substrate separating process (at step 1700) is executed. In this process, the suction of the real substrate by the substrate suction plate 4 is released, and the substrate returning conveyors 2a and 2b are ascended such that

the real substrate 22 is placed on the substrate returning conveyors 2a and 2b and is moved to the outside of the device.

[0063] And, it is determined whether all of the above-discussed processes are finished (at step 1800), and in a case where the paste pattern is coated by using the same paste pattern data on a plurality of real substrate sheets, the substrate mounting process (at the step 1400) is applied to another real substrate. When the series of processes are finished for all of the real substrates, the operation is completely finished (at step 1900).

[0064] In the preferred embodiment of the present invention, the nozzle is the working part and the substrate is the fixed part, but it is of course possible that the nozzle becomes the fixed part and the substrate becomes the working part.

[0065] Furthermore, in the preferred embodiment of the present invention, the simulation operations are executed by using the dummy substrate to previously determine the coating conditions of the paste pattern data to be coated, and therefore, there is no need for an unnecessary coating operation on the real substrate, thereby enabling the production ratio to be improved.

[0066] The coating conditions (that is, coating velocity, coating pressure and coating height) on the real substrate are determined in accordance with the straight line portion and the curved portion of the paste pattern, i.e. the shape of the paste pattern. Therefore, in the coating patterning of the paste pattern on the real substrate, the vibration of the working part (the nozzle or the real substrate) is substantially low, not giving any influence to the paste pattern to be patterned. Moreover, the coating precision is ensured to keep the amount of paste coating per unit time constant, and it is possible to coat the paste pattern of the desired shape with high precision.

[0067] Since the influence of vibration at the working part is great in the curved portion of the paste pattern, it is impossible to raise the coating velocity at the portion, but the coating velocity at the curved portion is set as the maximum coating velocity where the influence of vibration is little generated. Also, since the influence of vibration at the working part is weak in the straight line portion of the paste pattern, it is possible to raise the coating velocity at the portion. Therefore, a period of time consumed for the coating of the paste pattern is

reduced, and the coating and patterning of the paste pattern is executed, without any trouble, thereby achieving the improvement of productivity.

[0068]

[Effect of the Invention]

As set forth in the foregoing, according to the present invention, a maximum coating velocity is set in the range where the vibration of a working part can be suppressed, and a good quality of coating and patterning of the paste pattern of the desired shape is obtained, thereby achieving high productivity.

[Description of Drawings]

[FIG. 1] is a perspective view showing the structure of a paste coating device according to the present invention

[FIG. 2] is an enlarged perspective view showing the paste storage receptacle and the distance meter of FIG. 1.

[FIG. 3] is a block diagram showing the structure of the control unit and the control system of FIG. 1.

[FIG. 4] is a flowchart showing the whole operation of the preferred embodiment of the present invention in FIG. 1.

[FIG. 5] is a flowchart showing the vibration measurement process of FIG. 4.

[FIG. 6] is a flowchart showing the searching and determining processes for the paste pattern on which vibration is generated of FIG. 4.

[FIG. 7] is a view of describing processes of reading distance data, converting the read data, and determining whether the data is in an allowable range of FIG. 6.

[FIG. 8] is a flowchart showing a process of correcting coating conditions of FIG. 4.

[FIG. 9] is a view of describing the variation of the coating conditions by the process of correcting the coating conditions of FIG. 4.

[FIG. 10] is a view of describing the variation of the thickness of the paste pattern coated by a conventional paste coating device.

[Description of Reference Numerals]

1: mount

2a, 2b: substrate returning conveyors

4: substrate suction plate

5: θ -axis movement table

6a, 6b: X-axis movement tables

7: Y-axis movement table

8a, 8b, 10, 12, 24: servo motors

9: Z-axis movement table

10, 12: servo motors

13: paste storage receptacle

13a: nozzle

14: distance meter

17: control unit

22: substrate

23: paste pattern

25~29: encoders

30: positive pressure source

30a: positive pressure regulator

31: negative pressure source

31a: negative pressure regulator

32: valve unit

S: measuring point

L: laser light